Educational Administration: Theory and Practice
2024,30(7), 640 - 648
ISSN:2148-2403
https://kuey.net/

Research Article

Agricultural Digitalization In Indonesia: Challenges And Opportunities For Sustainable Development

Daniel Johan[1*], M Syamsul Maarif[2], Nimmi Zulbainarni[3], Budi Yulianto[4]

[1*]IPB University. sahabatdj.dprri@gmail.com
[2]IPB University. syamsul4958@gmail.com Orcid Scopus ID : 57189357943
[3]IPB University. nimmizu@apps.ipb.ac.id
[4]IPB University. bdylt71@gmail.com SB-IPB Building, Jalan Raya Pajajaran, Bogor City, West Java 16128

Citation: Daniel Johan, Et.al (2024), Agricultural Digitalization In Indonesia: Challenges And Opportunities For Sustainable Development, *Educational Administration: Theory and Practice*, *30*(7), 640 - 648
Doi: 10.53555/kuey.v30i7.6599

ARTICLE INFO

ABSTRACT

This study examines the current state of agricultural digitalization in Indonesia, focusing on its potential to transform the agricultural sector and improve farmer welfare. Using the Soft Systems Methodology (SSM), the research analyzes existing conditions, challenges, and opportunities in implementing digital technologies in agriculture. The study reveals that while agricultural digitalization is recognized as a priority in Indonesia's national development plans, its implementation faces significant hurdles. These include limited comprehensive regulations, uneven digital infrastructure, low digital literacy among farmers, and varying perceptions of technology adoption. The research highlights the need for an integrated approach involving key stakeholders such as the government, private sector, and farmers. The CATWOE analysis identifies farmers as primary beneficiaries and emphasizes the importance of tailored policies and infrastructure development. The study proposes recommendations for accelerating digital adoption, including formulating comprehensive regulations, improving rural digital infrastructure, enhancing farmer education programs, and strengthening the role of agricultural extension workers. The conceptual model developed through SSM provides a framework for creating an innovative and sustainable digital agricultural ecosystem. This research contributes to the understanding of agricultural digitalization in Indonesia and offers insights for policymakers and practitioners in developing effective strategies for digital transformation in agriculture.

Keywords: Agricultural Digitalization, Digital Infrastructure, Farmer Welfare, Indonesia, Soft Systems Methodology, Sustainable Agriculture

Introduction

The agricultural sector plays a crucial role in Indonesia's economy. According to data from the Ministry of Agriculture (2019), agricultural land in Indonesia covers 36,817,086 hectares, comprising paddy fields, dry fields, shifting cultivation areas, and temporarily unused land. This sector is one of the highest contributors to national economic growth, particularly during the COVID-19 pandemic. In 2021, the agricultural sector contributed 13.28% to GDP and grew by 1.84% (year-on-year) (BPS 2023). GDP growth by industry in 2022 shows that the agricultural sector ranked third after the industrial and trade sectors, reaching 12.40% (Prihandarini 2023). Moreover, this sector absorbs 38.7 million workers, or 28.61% of the total workforce in Indonesia, the largest among other sectors, with the trade sector ranking second at 26.19 million workers (BPS 2022).

Despite its significant role, the agricultural sector still faces various challenges. The vast agricultural land and the large number of farmers are not commensurate with productivity and farmer welfare (Ilyas 2022). This is influenced by various factors, such as increasing production costs, volatile agricultural input prices, and limited market access. Farmers, as key success factors in agriculture for producing domestic food, often have a significantly lower level of welfare compared to other sectors. Other factors affecting productivity include the quality of agricultural inputs, availability of irrigation water, use of technology, and agricultural digitalization.

In facing the challenges of the VUCA (Volatility, Uncertainty, Complexity, Ambiguity) era, digital transformation becomes a solution to increase effectiveness and efficiency in the agricultural sector (Bennis et al. 1985). Continuous changes in technology require society, including farmers, to follow the current technological developments. The VUCA phenomenon has emerged in the agricultural sector, such as volatility in agricultural input and output prices, complexity in food policies, and ambiguity in improving farmers' welfare. To address these challenges, the role of digital transformation is crucial.

Agricultural digitalization refers to the use of various technologies and digital data to enhance agricultural activities effectively and efficiently. Some technologies that have been used include Global Positioning Systems (GPS), Yield Monitors, remote sensing, and drones (Khanna 2020). In Indonesia's agricultural sector, digital utilization has begun with precision agriculture, such as determining the right time for fertilization, types of nutrients needed, pests damaging crops, and types of treatment. On a broader scale, the utilization of this digital transformation will increase work effectiveness and efficiency, as well as provide answers to challenges in the VUCA era.

The implementation of agricultural digitalization can help farmers increase productivity, resource use efficiency, and marketing of agricultural products at more favorable prices. Research shows that agricultural digitalization can increase farmers' income by up to 8.5% (Chulwa et al. 2022). Through social media, farmers can cut the supply chain from producers to consumers, significantly increasing farmers' profits (Banar 2019). In the Encomotion smart irrigation system, agriculture utilizing this technology statistically increases productivity by 40%, saves operational costs by up to 50%, and saves water and fertilizer by up to 40% (Wibowo 2021 in Permana 2021).

Agricultural digitalization has become a necessity in developing agriculture today, given the increasing food demand while agricultural land is shrinking. Based on BPS data (2019), agricultural land area in 2013 reached 7.75 million hectares but experienced a reduction of 0.35 million hectares, so that in 2019 it became 7.4 million hectares. The development of agricultural digitalization is a solution in addressing future food problems. From the on-farm side, agricultural digitalization can facilitate agricultural processing with the help of technology and encourage more valid mapping of agricultural areas. From the marketing side, agricultural digitalization also helps with the presence of various online platforms that facilitate agricultural products to be marketed and found by consumers.

The emergence of the phenomenon of the increasing role of the millennial generation in the economy, yet very few becoming farmers, as well as the strengthening role of digitalization coupled with the agricultural sector's continued positive growth during the pandemic, serves as a strong signal for improving the agricultural sector through agricultural digitalization efforts and encouraging the millennial generation to become farmers (Ilyas 2022). The application of information technology can be a solution to agricultural problems in Indonesia (Suweantara et al. 2017). One solution expected to help address problems in agriculture is the application of information technology in the form of rapidly developing digital applications. The government can play an active role in building this agricultural data infrastructure so that agricultural digitalization can be implemented properly. Thus, agricultural digitalization has the potential to change farmers' mindsets to maximize agricultural performance economically, socially, and environmentally (Harris and Fuller 2014).

In Indonesia, the implementation of agricultural digitalization has begun, albeit on a limited scale. This research aims to analyze the existing conditions of agricultural digitalization in Indonesia as a baseline in formulating strategies and policy recommendations. The importance of agricultural digitalization can be seen from its benefits in increasing productivity, efficiency in resource use, to direct marketing of agricultural products to consumers at prices more favorable to farmers. By specifically examining the application of agricultural digitalization, this research is expected to provide comprehensive recommendations for accelerating agricultural digitalization to increase productivity, farmer welfare, and national food security.

Methodology

Data for this research were collected from journals, scientific articles, and based on Statistics Indonesia (BPS) data from 2012-2022. This study required both primary and secondary data. To obtain an overview of the current agricultural conditions in Sambas Regency, West Kalimantan, a Focus Group Discussion (FGD) was conducted with 21 experts consisting of:

- 2 representatives from the Ministry of Agriculture
- 3 representatives from the central legislature (House of Representatives of the Republic of Indonesia), representatives from the West Kalimantan Agriculture Office, and representatives from the Sambas Regency Agriculture Office
- 2 agricultural practitioners
- 2 academics
- 2 members of the Sambas Regency legislature
- 2 agricultural business practitioners
- 2 community leaders from Sambas Regency
- 2 agricultural young business (millennials farmer)
- 4 agricultural extension workers

Data from the FGD results were formulated using the Soft Systems Methodology (SSM). SSM was employed to analyze problematic situations, issues, and strategic matters to develop a concept of agricultural digitalization aimed at improving agricultural performance in Sambas Regency, West Kalimantan Province.

Soft Systems Methodology (SSM)

Soft Systems Methodology (SSM) is a systematic method for developing information systems using a structured approach to understand problems, build conceptual models, obtain feasibility, desired changes, and implement them. SSM was first introduced by Checkland and his colleagues at Lancaster University. According to Nugroho (2012), SSM is a suitable method to help organizations visualize their goals by using human activity systems designed to achieve those goals. SSM has three main features:

1. Understanding and analyzing problem situations
2. Analyzing relationships and roles of related parties
3. Analyzing relationships between related parties and political and social roles

According to Davis and Girou (1996), SSM can be used to analyze information about unstructured human perceptions. Soft Systems Methodology is particularly useful for analyzing stakeholder perspectives from various fields to find solutions and solve problems. For an analysis related to real-world problems, the SSM information structure becomes more systematic (Bosch et al., 2007). In general, the soft systems methodology has seven stages, which can be seen in Figure 3.3 below:

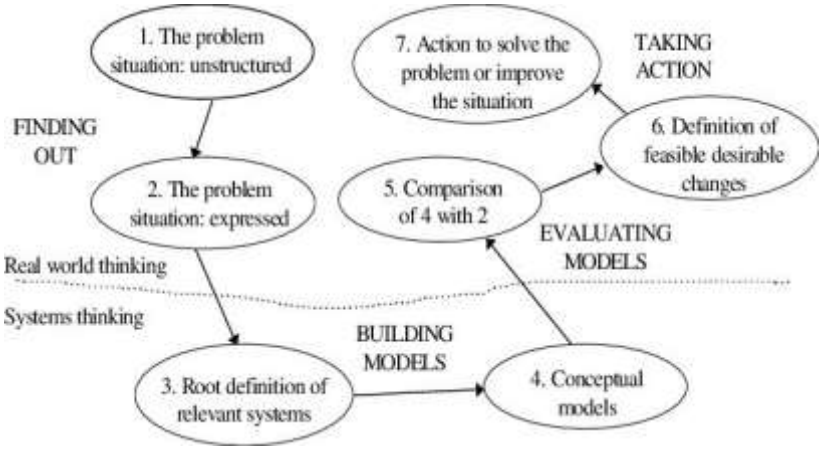

Figure 3.3 Stages of Soft Systems Methodology (SSM)

Results and Discussion

Agricultural digitalization refers to the application of information and communication technologies (ICT) in various aspects of agricultural activities. Its aim is to improve efficiency, productivity, and sustainability in the agricultural sector. This digitalization involves the use of various digital tools and platforms that assist agricultural actors in making more accurate and efficient decisions.

Agricultural digitalization in Indonesia is still in its early stages and has not been widely adopted by farmers. Some existing applications include mobile apps providing weather information, market prices, agricultural tutorials, and consultation services for farmers (such as Agree, iGrow, Plantix, Pak Tani Digital). However, based on cited research, only 30% of farmers use digitalization applications, while the remaining 70% have not yet utilized them. Some digital technologies that have begun to be used in Indonesia's agricultural sector include mobile applications, Internet of Things (IoT) for monitoring and automation in agricultural lands, agricultural information and management systems, data-based farming from sensors, drones, and satellites, and precision agriculture using GPS and GIS. However, the application of these technologies is still limited to certain scales and is not evenly distributed across all regions of Indonesia.

Some benefits experienced by farmers from the application of agricultural digitalization include an increase in farmers' income by up to 8.5% (based on cited research), cutting the supply chain so that farmers can sell directly to consumers at higher prices, productivity increases of up to 40%, and operational cost savings of up to 50% (Encomotion smart irrigation case study).

The following are the results and discussions obtained from each stage analyzed based on the phases built using the SSM technique. The first stage of SSM involves mapping the problematic situation, which begins with conducting focused group discussions with key individuals directly involved in Agricultural Digitalization, particularly officials/practitioners ranging from the Ministry of Agriculture, academics, to supporting partners, practitioners/observers from government agencies and organizational governance, researchers, and policy makers. The Focus Group Discussion (FGD) was held over a two-hour period. In addition to the FGD, direct visits and in-depth interviews with actors supporting Agricultural Digitalization were also conducted. The following are the findings from the interviews:

Table 1. Existing conditions of agricultural digitalization in Indonesia

No	Indicator	Existing conditions
1	Agricultural Land	Indonesia has vast potential agricultural land, reaching 11,479,847 hectares for food crops. However, this potential has not been maximized in production by farmers. Agricultural digitalization is expected to help farmers optimize the use of agricultural land more effectively and productively with the help of technologies such as precision agriculture, resource management, and so on.
2	Agricultural Digitalization	Agricultural digitalization is becoming the center of transformation in Indonesia's agricultural sector. This involves various parties such as telecommunication operators, agricultural technology providers, and digital private sectors. The implementation of agricultural digitalization faces several challenges, especially in the absence of regulations, including limited ICT infrastructure, limited internet access, and low digital literacy and technological skills.
3	Regulation	The main challenge in agricultural digitalization in Indonesia currently is the absence of regulations and policies that specifically and comprehensively support digital transformation efforts in the agricultural sector. Although some digitalization initiatives have begun, they are still partial and not well-coordinated. A strong legal umbrella and policies from both central and regional governments are needed to regulate, facilitate, and support the comprehensive implementation.
4	Infrastructure	The availability of adequate infrastructure is an important prerequisite in supporting agricultural digitalization. This includes the availability of widespread internet access to remote villages, strong telecommunication networks, and the provision of necessary digital devices and facilities. The lack of digital infrastructure in many agricultural areas is one of the obstacles in accelerating digital transformation in this sector.
5	Digital Literacy	The digital literacy gap between farmers and extension workers, educational institutions, and agricultural training becomes an obstacle in adopting agricultural digitalization. Many farmers, especially in rural areas, still have limited knowledge and skills in using digital technology. Massive efforts are needed to improve farmers' digital literacy through intensive education, training, and mentoring programs by extension workers and related institutions.
6	E-Commerce	The presence of e-commerce and private digital trading platforms can help farmers improve their bargaining position by selling agricultural products directly (direct selling) to consumers. This eliminates the role of intermediaries or middlemen who have historically given farmers a low bargaining position. E-commerce becomes a digital marketplace that facilitates farmers to sell their products directly at more profitable prices.
7	Stakeholders	Farmers: Main actors in the agricultural sector who have land potential but still have a low bargaining position against middlemen Extension Workers: Play an important role in encouraging the adoption of agricultural digitalization by providing education, training, and mentoring to farmers to increase their digital literacy. Government (Central and Regional): Responsible for formulating regulations and policies that support agricultural digitalization comprehensively, from legal frameworks, infrastructure, funding, to technology standardization Middlemen: Currently still have a strong bargaining position against farmers due to farmers' limited access to markets Private Sector (e-commerce, telecommunication operators, agricultural technology providers): Play a role in providing various digital services, products, and infrastructure to support agricultural transformation.

Figure 1 illustrates the second stage of SSM, which involves creating a Rich Picture that depicts the existing conditions of Agricultural Digitalization in Indonesia.
This figure was developed comprehensively by considering variables such as Agricultural Land, Agricultural Digitalization, Regulations related to agricultural digitalization, Infrastructure, Digital Literacy, and E-Commerce, as well as current activity logs.

The figure consists of several icons representing key elements that contribute to the overall well-being of the agricultural digitalization environment.

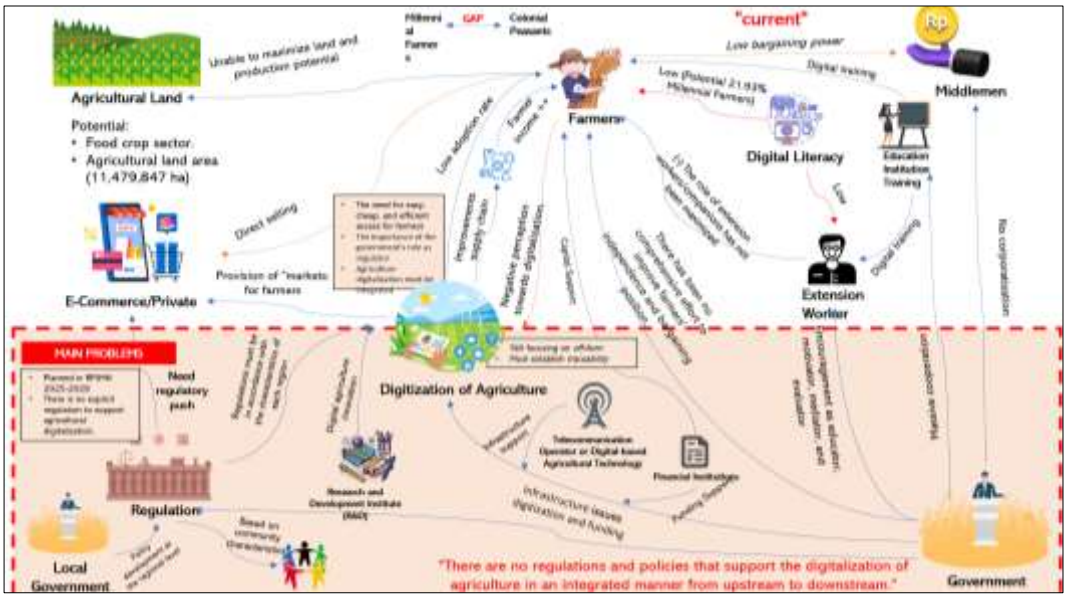

Figure 1 Rich Picture of the existing of agricultural digitalisation in Indonesia

The Indonesian government has established agricultural digitalization as one of the priority agendas in the 2025-2029 National Medium-Term Development Plan (RPJMN) with various priority projects such as the provision of weather sensors, drones, smart greenhouses, digitalization of agricultural land, and development of agricultural digital platforms. However, its implementation still requires close cooperation between the government, technology companies, agricultural organizations, and academics to develop solutions that meet local needs. Supporting infrastructure such as internet access and digital devices remains a major obstacle in implementing agricultural digitalization in Indonesia, especially in rural areas. The government needs to increase investment in ICT infrastructure development in rural areas to support the adoption of digital technology by farmers. Overall, agricultural digitalization in Indonesia is still in its early stages and requires coordinated efforts from various stakeholders to accelerate the adoption of digital technology in the agricultural sector. This is important to improve agricultural productivity, efficiency, and sustainability, as well as improve farmer welfare and national food security.

The third and fourth stages of Soft Systems Methodology (SSM) are determining the Root Definition (RD) and developing the Purposeful Activity Model (PAM). Root Definition is a clear statement describing the activities that occur, or may potentially occur, in agricultural digitalization in Indonesia, formulated as follows:

1. (P): Implementation of digital technology in agriculture
2. (Q): By developing and implementing digital tools and platforms that facilitate better farming practices, data management, and direct market access for farmers.
3. (R): To increase agricultural productivity and improve farmer welfare, thereby supporting the growth and sustainability of the agricultural sector.

Using the Root Definition as a foundation, a conceptual model is then developed and further compiled into CATWOE. The 3E performance measurement criteria (effectiveness, efficiency, and efficacy) are used to assess system performance. In practice, performance measurement criteria have evolved into 5E (efficacy, efficiency, effectiveness, elegance, and ethics) to measure system performance. CATWOE analysis on agricultural digitalization in Indonesia is presented in Table 2.

Table 2: CATWOE Analysis

Simbol		Description
C	**Customers**	Farmers, including agripreneurs, who will directly feel the impact of agricultural digitalization. They are the main beneficiaries of this system, which is expected to experience increased productivity and welfare through the use of digital technology in their agricultural activities.
A	**Actors**	Government as regulator and policy provider, digital service providers, agricultural extension workers, financial institutions, and of course the farmers themselves who will use digital technology in their agricultural practices.
T	**Transformation Process**	Adoption and integration of digital technology in agricultural activities aimed at improving efficiency, productivity, and quality of agricultural outputs. This includes the use of agricultural information systems, mobile applications for

		weather monitoring and market prices, and digital platforms for marketing agricultural products.
W	**Worldview**	Agricultural digitalization is an important step to address traditional agricultural challenges, increase the competitiveness of the agricultural sector, and ensure the sustainability of food production in the modern era.
O	**Owners**	Government and institutions that have the authority to create and implement agricultural policies, which have the power to change or maintain the system in accordance with established policies.
E	**Environmental Constraints**	Environmental constraints include uneven technological infrastructure, limited access to technology for farmers, climate change affecting agricultural practices, and policies and regulations that can affect the implementation and effectiveness of agricultural digitalization.

Agricultural digitalization is a strategic step in facing the challenges of the agricultural sector in the modern era. The main focus of this initiative is farmers and agripreneurs, who are expected to be direct beneficiaries of digital transformation in agricultural practices. This process involves various key actors, including the government as regulator and policy provider, digital service providers, agricultural extension workers, financial institutions, and of course the farmers themselves as end-users of the technology.

The proposed transformation includes the adoption and integration of digital technology into agricultural activities, with the main goal of improving efficiency, productivity, and output quality. This includes the use of agricultural information systems, mobile applications for weather monitoring and market prices, and digital platforms for marketing agricultural products. From a global perspective, agricultural digitalization is seen as an important solution to overcome the limitations of traditional agriculture, increase sector competitiveness, and ensure the sustainability of food production.

In the context of Soft Systems Methodology (SSM), the conceptual model is developed as an intellectual tool to discuss complex situations. This model in Figur 2 includes analysis of traditional agricultural practice conditions, digital technology adoption processes, and the creation of an innovative and sustainable digital agricultural ecosystem. The government and authorized institutions act as system owners, having the power to change or maintain the system according to established policies.

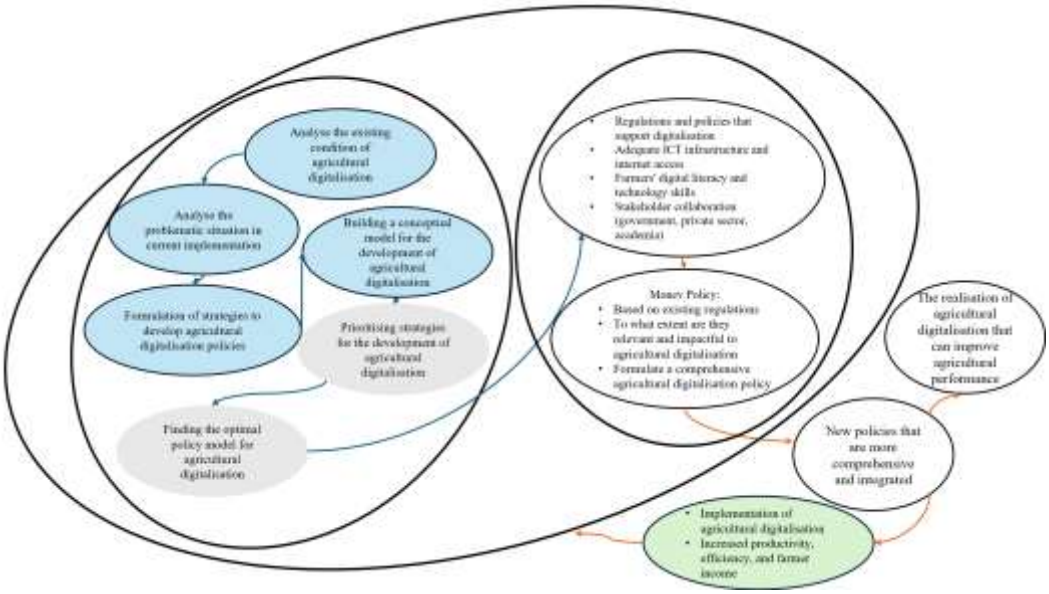

Figure 1 Conceptual Model of Agricultural Digitalization

The conceptual model of agricultural digitalization in Indonesia places regulations and policies as the main foundation in the digital transformation of the agricultural sector. The success of this initiative depends on strong, harmonious, and conducive regulatory support at all levels of government. Formulated policies must consider the specific needs of agricultural sector actors, especially farmers as the main actors, and create a stable environment for digital investment and innovation. The development of equitable and quality digital infrastructure becomes a key component in this model. The availability of internet networks, electricity resources, and adequate hardware is seen as an important prerequisite for realizing inclusive agricultural digitalization. Policies that support digital infrastructure investment need to be integrated into a broader regulatory framework.

This model also emphasizes the importance of a comprehensive understanding of the agricultural digitalization ecosystem. Outlining the roles and interactions between stakeholders, including farmers, technology providers, government, and academics, is seen as a crucial step in identifying opportunities for collaboration

and synergy. Regulations are expected to encourage coordination and partnerships between stakeholders to create a mutually supportive ecosystem. Another important aspect is the utilization and protection of agricultural data. This model underlines the importance of regulations governing the collection, use, and protection of data to maintain farmer trust and promote the adoption of digital technology. Policies also need to encourage the use of data for optimizing agricultural inputs, improving supply chain efficiency, and increasing farmers' access to markets.

Human capital development becomes an important focus, with regulations expected to support comprehensive and inclusive training, education, and mentoring programs to increase farmers' capacity to adopt digital technology. Policies that encourage digital literacy are considered crucial in overcoming the digital divide. This model also encourages the identification and mitigation of potential risks and challenges in agricultural digitalization. Regulations need to anticipate and address issues such as the digital divide, data security, and sustainability through a holistic and collaborative approach. Farmers, as the main actors, occupy a central position in this model. Regulations need to consider the socio-economic characteristics of farmers and encourage their active involvement in the development and implementation of digital solutions. Policies that support incentives, protection, and empowerment of farmers are seen as key to increasing the adoption and sustainability of digital technology.

Finally, this model emphasizes the importance of strategic orchestration in the agricultural digitalization ecosystem. Regulations are expected to facilitate close coordination and collaboration between stakeholders to realize an inclusive and sustainable digital transformation. An integrative and participatory approach needs to be encouraged through policies that support the formation of collaborative platforms and innovation networks. With this conceptual model, it is hoped that the involved actors will have a better understanding of the activities and strategies that need to be carried out to realize successful and sustainable agricultural digitalization. The performance of this system can be measured using five established criteria as follows.

Table 2 Performance Measurement Criteria for the System's Activities

5 E's criteria	Description
Efficacy	Creating an innovative and sustainable digital agricultural ecosystem in Indonesia by increasing technology adoption, productivity, and access to information for farmers, thereby improving agricultural performance (farmer prosperity).
Efficiency	Optimizing the use of agricultural resources, reducing operational costs, and improving supply chain efficiency through the application of digital technology.
Effectiveness	Improving farmer welfare, strengthening national food security, and increasing the competitiveness of Indonesian agricultural products in the global market.
Elegance	Developing digital solutions that are easy to use, integrated, and adaptive to farmers' needs and technological developments.
Ethicality	Upholding ethical principles in the implementation of agricultural digitalization, protecting farmers' data, and ensuring fair benefits for all stakeholders.

The comparison between the activities of the conceptual model and real-world conditions results in the implementation or activity gaps and requires changes in activities, as shown in Table 3.

Table 3 Comparison of Conceptual Model with Real-World Conditions for Agricultural Digitalization in Indonesia

No	Aspect (Key Factor)	Conceptual Model	Real-World Condition	Possible Improvements
1	Regulation	Comprehensive and integrated regulations to support holistic agricultural digitalization.	Existing regulations are still partial and not well integrated.	Develop more comprehensive and integrated regulations, providing a strong legal framework for the implementation of agricultural digitalization.
2	Infrastructure	Availability of adequate and equitable digital infrastructure	Information and communication technology (ICT)	Improve the availability and quality of digital infrastructure through cooperation between government,

No	Aspect (Key Factor)	Conceptual Model	Real-World Condition	Possible Improvements
		across agricultural areas.	infrastructure is still limited, especially in rural areas.	telecommunications operators, and the private sector.
3	Farmer Characteristics	Enhance farmers' capacity and skills in adopting and utilizing digital agricultural technology.	Farmers have varying levels of education and digital literacy, mostly still low.	Adjust education and training programs considering farmer characteristics, and provide intensive assistance in applying digital technology.
4	Farmer Perception	Build positive farmer perceptions towards the benefits and ease of use of digital technology in agriculture.	Farmers still have doubts and resistance to adopting digital technology as it is perceived as complex and expensive.	Socialize and demonstrate the benefits of digital technology directly to farmers, and provide incentives and support for technology adoption.
5	Role of Facilitators	Optimize the role of agricultural extension workers and facilitators in encouraging the adoption of agricultural digitalization by farmers.	Agricultural extension workers are not fully prepared and trained to assist farmers in adopting digital technology.	Enhance the capacity and skills of agricultural extension workers in digital technology, and strengthen collaboration with research institutions and agricultural technology providers.

Although agricultural digitalization in Indonesia has been recognized as a priority agenda in the 2025-2029 National Medium-Term Development Plan (RPJMN) and various initiatives have been undertaken to increase productivity and farmer welfare, there are still significant challenges hindering its comprehensive implementation. Based on the SSM analysis conducted, it was found that existing regulations are still partial and not well integrated, digital infrastructure in rural areas is still limited, and digital literacy among farmers is still low. Additionally, farmers' perceptions and readiness towards digital technology still require improvement through more intensive education and assistance. Currently, there is no comprehensive explicit policy to support the sustainability of the digital agriculture ecosystem. Therefore, further analysis is needed to assess the impact of various existing policies and formulate the most effective and efficient regulations. Through this approach, it is expected that the resulting regulations can provide a strong legal umbrella and optimal support for the implementation of agricultural digitalization in Indonesia.

Managerial Implications

The managerial implications of this research are the efforts to develop an agricultural digitalization policy model to support the improvement of agricultural performance in Indonesia. The results of this research are the results of scientifically sound academic analysis that provide ideal recommendations for an agricultural digitalization policy model in Indonesia. This research produces several important findings that have managerial implications for the development of agricultural digitalization policies in Indonesia, namely:

Encourage the emergence of comprehensive and integrated national policies related to agricultural digitalization.
This research produces a comprehensive and integrated agricultural digitalization policy model that covers aspects of regulation, capacity development, institutional strengthening, digital ecosystem development, and the use of digitalization to increase productivity and farmer welfare. This model can be a reference for policymakers in designing and implementing effective and pro-farmer agricultural digitalization policies.

Conclusion and Recommendations

Agricultural digitalization has become a priority agenda in the development of Indonesia's agricultural sector, with the expectation of increasing productivity, efficiency, and farmer welfare. However, its implementation

still faces various challenges, as revealed by the analysis of existing conditions using the Soft System Methodology (SSM) approach. These challenges include limited comprehensive regulations, uneven digital infrastructure, and low digital literacy among farmers.

The SSM analysis, including the CATWOE analysis, identified gaps between the conceptual model and real-world conditions in aspects of regulation, infrastructure, farmer characteristics, perceptions, and the role of facilitators. Farmers were identified as the main customers, with the government and other stakeholders as key actors in the transformation process of adopting and integrating digital technology in agriculture.

Based on these findings, several recommendations are proposed. There is a need to formulate comprehensive and integrated regulations to provide a strong legal framework for agricultural digitalization. Efforts should be made to improve the availability and quality of digital infrastructure, especially in rural areas, through cooperation between government, telecommunications operators, and the private sector. Education and training programs should be adjusted to match farmers' characteristics and needs, including strengthening the capacity of agricultural extension workers in digital technology.

Furthermore, it is crucial to intensify socialization and demonstration of digital technology benefits to increase farmers' awareness and interest in adoption. Strengthening collaboration among government, private sector, academics, and farmers is essential to create an inclusive and sustainable agricultural digitalization ecosystem. A comprehensive monitoring and evaluation system should be developed to measure progress and impact of agricultural digitalization implementation.

The performance of these initiatives can be measured using the 5E criteria: efficacy, efficiency, effectiveness, elegance, and ethicality. This study, while focused on conditions in Sambas Regency, West Kalimantan, provides insights for broader implementation. Further research with a wider scope is needed for a more comprehensive understanding of agricultural digitalization in Indonesia.

By implementing these recommendations, Indonesia can accelerate the adoption of digital technology in agriculture, potentially increasing sector productivity and competitiveness, and ultimately improving farmer welfare. The key to realizing this inclusive and sustainable digital transformation lies in close collaboration among all stakeholders in Indonesia's agricultural sector. Through these concerted efforts, it is hoped that the challenges in implementing agricultural digitalization can be effectively addressed, paving the way for a more technologically advanced and prosperous agricultural sector in Indonesia.

References

1. Central Statistics Agency. 2022. Official Statistics News.
2. Banar PS. 2019. Benefits of Social Media Use for Horticulture Farmers in Bulukerto Village, Bumiaji District, Batu City, Malang: Brawijaya University.
3. Bennis WG, Nanus B, Bennis S. 1985. Leaders: Strategies for Taking Charge (Vol. 200). New York: Harper & Row.
4. Bosch, Ockie, King, C, Herbohn, John, Russell, Iean, Smith C. 2007. Getting the big picture in natural resource management-systems thinking as 'method' for scientists, policy makers and other stakeholders. Systems Research and Behavioral Science. 24. 10.1002/sres.818. DO- 10.1002/sres.818. JO - Systems Research and Behavioral Science.
5. Harris DR, Fuller D Q. 2014. Agriculture: definition and overview. Encyclopedia of Global Archaeology, 104–113. doi:10.1007/978-1-4419-0465-2_64
6. Ilyas. 2022. Optimalisasi peran petani milenial dan digitalisasi pertanian dalam pengembangan pertanian di Indonesia. Forum Ekonomi: Jurnal Ekonomi, Manajemen dan Akuntansi. 24(2): 259-266. DOI: https://doi.org/10.308872/jfor.v24i2.10364.
7. Khanna M. 2020. Digital Transformation of the Agricultural Sector: Pathways, Drivers and Policy Implications. Applied Economic Perspectives and Policy. 43: 1221-1242.
8. Kirkpatrick C, Parker D. 2004. Regulatory Impact Assessment And Regulatory Governance In Developing Countries. Wiley InterScience. DOI: 10.1002/pad.310.
9. Permana A. 2021. Digitalizing Agriculture: A Path to Food Security and Sustainable Production. online
10. Prihandarini R. 2023. Selected Topics in Organic Agriculture and Environmentally Friendly Agriculture. Serang(ID): A-Empat.
11. Suweantara E, Martana GSA, Surya A, Widiartha IM. 2017. Proceedings of the National Seminar on Information Technology and Its Applications. 2017: 142-150.